

Two New Tiger Beetles of the Genus *Cicindela* from Western United States (Cicindelidae: Coleoptera)

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Abstract.—Two new subspecies of *Cicindela* are described: *C. scutellaris yampae* of northwestern Colorado, and *Cicindela formosa rutilovirescens* of eastcentral New Mexico. Both subspecies are found at the periphery of the ranges of their respective species. This study traces their migration into their present locations in an attempt to define the forces that cause changes leading to subspeciation. *C. scutellaris* is retained as a species group because of the singularity of parts within the internal sac of the aedeagus in the male genitalia. *C. formosa* is significantly different in both male and female genitalia from other members of Rivalier's Group VII so that it constitutes a separate group of its own. Rivalier's Group VII should be renamed the *Purpurea* Group.

The two subspecies described in this paper belong to the tiger beetle species *Cicindela scutellaris* and *C. formosa*. They represent populations located at the limit of the known ranges of these species where contact with other populations has not happened for a long time. Thomas Say described *C. formosa* (1817:19) and *C. scutellaris* (1823:40) from midwestern United States populations that were found sympatrically in sand blowouts, or, as Say called these, "sand alluvions." Both species have extensive ranges sufficiently varied to have resulted in subspeciation. It can be generalized that wherever *C. formosa* is found *C. scutellaris* will occur, but the reverse is not always so because *C. scutellaris* has extended its range into southeastern United States by invading sandy woodlands.

Key to the Subspecies of *Cicindela scutellaris*

1. Bicolored: Head and pronotum bright green, blue-green or blue: elytra from a bright red (sometimes alutaceous), to a darker red 2
- Unicolored, where head, pronotum and elytra are the same background color, sometimes with variations 3
2. Elytra immaculate *scutellaris*
- Elytra with a continuous white maculation at outer edge, with a confused area at middle band position; rarely reduced to broad spots at outer edge *yampae*
3. Color bright to dark red, sometimes suffused with green 4
- Color bright green to deep violet-blue. Variable in size depending on subspecies 6
4. Maculation consisting of white dots on outer edge of elytra *lecontei*
- maculation connected at outer edge of elytra 5
5. Broad maculation at outer edge of elytra, with a non-confused broadened middle area *criddlei*

- Maculation reduced to outer edge dots, infrequently narrowly connected *rugifrons*
- 6. Smaller (10–11 mm long). Dark blue, blue-green or green, sometimes with apical dots *unicolor*
- Larger (11.5–12.5 mm long) 7
- 7. Color purplish or blue-green *rugata*
- Color yellow-green *flavoviridis*

Cicindela scutellaris yampae, new subspecies

Figure 1 (1)

Holotype. — Male, in the collection of the American Museum of Natural History (AMNH), New York, NY: collected by Mont A. Cazier, September 1953.

Locality. — Maybell Sand Hills which lie between two and 6 km east of Maybell, Moffat County, Colorado. All specimens of the type series were captured in this region. The first 51 specimens by M. A. Cazier in 1953. The remaining specimens of this series were collected between June 1959 and April 1983.

Type series. — There are 370 specimens in the series, distributed as follows: Holotype and 26 paratypes in the collection of the AMNH, New York, NY; allotype female and 80 paratypes (41 ♂, 39 ♀) in my collection designated the NLRC by Arnett et al. (1969:28). The remainder are in the following collections: two at the National Museum of Natural History (NMNH), Washington, DC; two at the California Academy of Sciences (CAS), San Francisco, CA; Walter Johnson, Minneapolis, MN, 13 specimens; David W. Brzoska, Lawrence, KS, 149 specimens (88 ♂, 61 ♀); Howard P. Boyd, Vincentown, NJ, 37 specimens (21 ♂, 16 ♀).

Description. — Medium size, robust; head and pronotum bluish-green, elytra red with golden birefringence, and broad band of maculation along outer edge which broadens out into confused pattern where middle band would enter normally.

Head: Color mostly bright bluish-green, more green at vertex and near eyes, interocular space nearly blue; only slightly wrinkled at vertex, more so on frons; interocular striae not deep; frons punctured and bearing many decumbent setae; setae between eyes nearly erect but spaced in growth of medium density; clypeus green, blue toward the outer edges, bare; labrum white, outer edges dark, six long white setae near outer edge, tridentate and extended forward but less than half as long as wide; penultimate labial segment longest, heavily setose and metallic blue in color, terminal segment similarly pigmented but bare; segments of labral palpi metallic blue, second segment longest and heavily setose, outer two bare except for a few setae near anterior surface of penultimate segment; first four segments of antennae green, first large and covered with many punctures bearing long white erect setae on anterior surface only, length of fourth segment seven-eighths that of third.

Thorax: pronotum narrower than head across eyes, wider than long by more than one-fifth; color green, disc golden, margins bluer, wrinkled; median sulcus blue and shallow, crossed with transverse impressions; anterior sulcus blue, deep, micro-reticulated anteriorly only, not wrinkled; posterior sulci also blue and deep; longitudinal row of white, erect setae two-thirds distance from centerline, another row of setae at epipleural edge, recumbent toward center, but distinct from very long sub-epipleural setae.

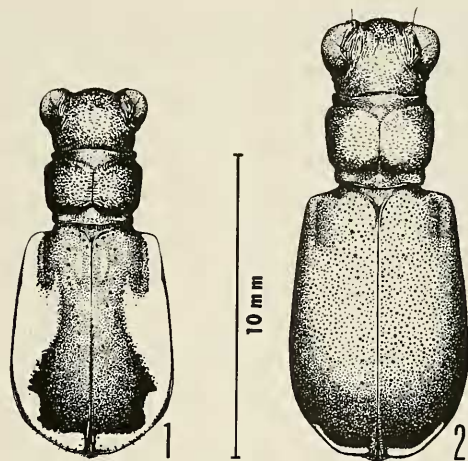


Fig. 1. Dorsal views. 1. *Cicindela scutellaris yampae*, 2. *C. formosa rutilovirescens*.

Elytra: Broad, widest posterior to middle; micro-reticulate and covered with very small impressions, surface transparent in appearance with birefringence of golden green on disc against basic red color; disc with row of very small setigerous punctures near suture; another short row of punctures located in humeral impressions that delimit disc; maculation continuous at outer edge of elytra but lunules and middle band traceable, pattern as in Figure 1 (1); pigment at discal edge of maculation deeper red, almost purple in small impressions.

Venter: Bright greenish-blue throughout; genae with longitudinal stria, glabrous; epimera and coxae with numerous long setae; femora and tibia greenish blue, with long white setae, tibiae more densely covered with setae, tarsal claws nearly as long as last tarsal segment; penial notch present as a slight declivity on penultimate sternite.

Comment.—Females are similar to males, both in size and proportion, but differ in that the frons is nearly glabrous.

Dimensions.—Holotype, male—length 11.8 mm, width 4.9 mm. Allotype, female—length 12.0 mm, width 5.1 mm.

Etymology.—Named for the Yampa River Valley of Utah.

Population variables.—In a population sample of 56 specimens studied in more detail, the most striking variations are in color and maculation.

Color: The head and pronotum are green in 51 specimens, blue in four, and golden green in one. Elytra are red, varying between dark red and golden red, superimposed with varying amounts of green suffusion—the darker the red, the less the green suffusion.

Maculation: In 46 specimens the maculation is connected along the entire margin of the elytra. In four specimens the humeral lunule, or dot, is disconnected from the marginal band. In seven specimens the maculation is reduced to marginal dots, and in two cases, the humeral dots are lacking. In all samples the middle band consists of an expansion from the outer edge toward the center of the elytra, with a confused area at the basal edge in the majority of specimens. In 27 specimens this confused area expands considerably anteriorly toward the base of the elytra

such that these specimens are more heavily maculated than the rest. Of the more heavily maculated specimens 23 have epicentral spots which, in some cases, consist of a narrow vertical line bordered by a purplish-red pigmentation; in two cases the white disappears, but the area is marked by the deeper red color.

Conclusions Based on Faunal Distribution

1. During the glacial periods of the Pleistocene, a broad region of southcentral Wyoming became a refugium for a number of Canadian species of *Cicindela*. The species most sensitive to change developed noticeable characteristics in response to climate change, and possibly through some hybridization. This seems to have been the situation with *C. scutellaris*.

2. A region of northern Montana, centered around Great Falls, was an isolated haven for species from Alberta as they migrated southward ahead of glacial advances. Here, the environmental impact on *C. scutellaris* was slight, thereby inducing only slight color change. Thus, the climate in this region was hardly more severe than today's climate in central Alberta.

3. Isolated populations of *C. scutellaris*, *C. formosa* and *C. limbata* may still exist in the Bighorn and Powder River Basins. The discovery of such populations would aid in tracing the migratory routes of these species.

Key to the Subspecies of *Cicindela formosa*

1. Elytra broadly maculated 2
- Elytra immaculate or narrowly maculated 4
2. Broad white maculation of elytra consisting of humeral and apical lunules, and a middle band; all narrowly connected at edge 3
- Maculation coalesced into total coverage of elytra *gibsoni*
3. Bright red in color. Midwestern form *formosa*
- Dark brown in color. Eastern form *generosa*
4. Elytra with apical lunule white, often with other lunules pigmented, or lacking. Color dark red with upper half of elytra a deep purple *pigmentosignata*
- Elytra with either narrow apical lunule only or none at all. Color bright red with green birefringence *rutilovirescens*

Cicindela formosa rutilovirescens, new subspecies

Figure 1 (2)

Holotype.—Male, no. 12984 in the collection of the CAS, San Francisco, CA, captured by Mont A. Cazier, October 1953.

Locality.—The type location is in the Mescalero Sands, 55 to 65 km due east of Roswell, New Mexico, in the eastern part of Chaves County, at a mean elevation of 1300 m. The sands trend from southwest to northeast for nearly 50 km, their width varying from 6 to 14 km. The area is made up of low hills, 2 to 3 m high, covered with a short scrub oak (*Quercus harvardi*) which partially stabilizes the sand, although in a few places bare dunes rise to heights not exceeding 8 m. The ground sand is light in color, somewhat darker where vegetation growth contaminates it with debris. The innumerable blowouts in the troughs of the oak-covered area are bare.

Type series.—There are 185 specimens from the type area, distributed as follows: Holotype male and three paratypes at the CAS; allotype female and 28 paratypes in the NLRC, collected in October 1953 by M. A. Cazier, in September 1957 by E. Tinkham, and at various times by me from 1960 to 1980. Paratypes are in the private collections of the following individuals: W. D. Sumlin, 12 (3 ♂, 9 ♀); E. V. Gage, 3 (2 ♂, 1 ♀); G. Gaumer, 30 captured in May 1971; D. Brzoska who collected in May and September from 1978 to 1982, 56 (35 ♂, 21 ♀); J. Stamatov, 27, and H. Boyd, 23 specimens which they collected in September 1976.

There are 24 paratypes from locations other than the type area which are distributed as follows: One female from Terry County, TX collected by D. Kelly deposited in the collection of Walter Johnson; eight specimens collected east of Plains, Yoakum County, TX, two of which are in the NLRC; one from SSE of Loco Hills, Eddy County, NM by G. Gaumer in September 1971; three from Portales, Roosevelt County, NM in the East New Mexico University collection; one male in the NLRC collected by J. Sheppard in May 1974 south of Milnesand, Roosevelt County, NM.

Description.—Large in size, form robust, upper surface red, birefringent with green, with only slight indication of maculation at apex of elytra.

Head: Bright golden red vertex finely wrinkled, interocular striae brightly colored red with golden tinges; frons wrinkled and punctate, greenish at edges, bright deep blue toward antennae, punctures with long white setae, nearly recumbent anteriorly, anteriormost setae lying toward vertex, middle setae lying toward sides, and sparse setae between eyes lying generally toward middle; clypeus bright blue, violaceous toward sides; first four segments of antennae green, first segment with three or four setae from middle to apex on outer edge, four or five setae around apex and near base of second segment, with third segment nearly one-third longer than fourth; labrum tridentate, extended forward, one half as long as wide, whitish with outer edge dark, six setigerous punctures near outer edge; long heavily setose penultimate labial segment nearly 1.5 times as long as glabrous last segment, both metallic blue; second labral palpal segment unpigmented with white setae on basal half, 2.1 times longer than penultimate segment and 1.3 times longer than last segment, both of the latter metallic green.

Thorax: Pronotum nearly as broad as head, ratio of width to length = 1.15 and broadest just basal to anterior transverse impression, tapered to rounded posterior angle; surface finely rugose; median sulcus of disc shallow, anterior and posterior sulci deep; color red with golden tinge, more so laterally and at bottom of impressions; two rows of recumbent setae, one near lateral edge, other just above epipleurae; venter bright violaceous blue; all three thoracic sterna and coxae with medium growth of long white setae.

Elytra: Wider at shoulder than head, tapered slightly wider for two-thirds, then broadly rounded to apex; entire elytral surface micro-reticulate, impressed throughout with minute shallow pits, each with slightly raised anterior edge; one row of very small setigerous punctures near suture, not readily seen except under magnification, entire surface with birefringent transparency such that surface appears red when viewed from above, but when viewed from oblique angles it appears greenish; outer edge narrowly bluish green at epipleural ridge; no mac-

ulation except for barely visible narrow band of white representing vestigial apical lunule.

Venter: Deep metallic violaceous blue; genae wrinkled, with a few recumbent setae ventrally and remote from the eyes; all sterna and coxae covered with medium growth of long white decumbent setae; trochanters galbrous except for one long setigerous puncture at apex; femora and tibiae blue, with long white setae; tarsi dull bluish green, each segment with a few pits near apex from which rise long setae; tarsal claws long, those of hind tarsus nearly as long as last tarsal segment; all segments of abdomen sparsely covered with white setae; penial notch symmetrical but shallow.

Dimensions.—Female slightly longer and proportionately broader than the male. Holotype male—Length 12.0 mm, width 5.8 mm. Allotype female—length 16.2 mm, width 6.8 mm.

Etymology.—Named for its primary color red (*rutilis*), and its secondary green (*viridis*) birefringence.

Population variables.—Of 85 specimens studied in detail 13 were completely immaculate. Nearly all the rest appeared to be immaculate also, but actually bore either a minute apical spot, or a very thin white line that paralleled the apical portion of the elytra for a short distance, but not recurved. Only one specimen had markings consisting of a narrow uninterrupted humeral lunule, a thin middle band without recurved tip, the latter connected along the edge to a thin apical lunule.

The degree of color transparency is varied. Nearly one third of the specimens studied had a deeper color. When viewed from above they appeared less birefringent than the lighter colored specimens.

Hybrid populations.—The slight variations in color and maculation reported above suggest that intergradation of this form with *C. f. formosa* has occurred where the Llano Estacado blends into the Great Plains to form the hybrid population of *rutilovirescens* $\times$ *formosa*. Such hybrids were taken by G. Gaumer in Texas, both at Muleshoe, Bailey County and north of Sudan, Lamb County in October 1971. D. Brzoska located another hybrid group north of San Jon, Quay County, New Mexico. Of six specimens from San Jon, two are similar to ssp. *rutilovirescens*, one with a high degree of birefringence, the other a darker red; another is similar to ssp. *formosa*, whereas the other three have narrower maculation with short middle band, one with some birefringence.

On the Status of *Cicindela formosa manitoba*

In the northwest region of the Great Plains, in a broad area encompassing parts of the United States and Canada, the maculation of *Cicindela formosa* broadens until the limit is reached where the elytra are nearly white. *C. f. manitoba* was described by C. W. Leng (1902:137) from broadly marked Manitoba populations, many years before still more broadly marked populations were discovered farther west, in Saskatchewan, and subsequently described by W. J. Brown (1940:181) as *Cicindela formosa gibsoni*. This last subspecies represents the broadest maculation form, a condition mentioned earlier as having been associated with migration to an area where such a type of maculation was common to several related species of *Cicindela*. *C. f. gibsoni* developed through isolation, whereas *manitoba* is a hybrid created wherever ssp. *gibsoni* and ssp. *formosa* met upon returning

north during Pleistocene interglacials. Therefore, the name *manitoba* has no status in the nomenclature, and as such becomes a junior synonym of *C. formosa*.

Systematics of *Cicindela scutellaris* and *Cicindela formosa*

An early attempt to classify the Cicindelidae of the United States was made by J. L. LeConte (1856:33–40). He placed *Cicindela scutellaris* in a Group VI with *C. pulchra*, *C. lecontei*, and *C. nigrocoerulea*. *Cicindela formosa* was placed in Group VII with *C. ancocisconensis*, *C. venusta* (= *C. lengi*), *C. vulgaris* (= *C. tranquebarica*) and *C. fulgida*. The LeConte classification was based largely on similarities of markings, and to a lesser extent on punctuation and pilosity. Leng (1902:124–125), in his revised classification, altered the LeConte scheme by placing *C. scutellaris* in a group by itself. Leng (1902:135) placed *C. formosa* with *C. late-signata* and *C. tenuicincta*. W. Horn (1926:262) took a broader view by combining some Nearctic Cicindelidae into a *Formosa*—*purpurea*—*oregona* Group. Here, he included both *C. scutellaris* and *C. formosa*. In his Catalogue, Leng (1920:40) reflects the Horn viewpoint.

In 1954, Rivalier revised the Nearctic genus *Cicindela* under an earlier stated intention (Rivalier 1950:15) to dismember the classical genus *Cicindela* into a number of new genera. The primary method to accomplish this was based on a comparative study of the structures within the aedeagus. The intention of my paper is to go a step further and use the genitalia of both sexes. The aedeagi of the males, and the female external genitalia (those parts used to dig holes in which to deposit eggs), are shown in Figures 2 through 5. The definition of terms to describe the aedeagus are the same used earlier (Rumpp 1967:134). Those used to describe the female parts are the same as used by V. M. Tanner (1927).

Genitalia of *Cicindela scutellaris*

Figures 2 and 3

Male.—Nineteen aedeagi were examined, some in the resting position, some everted. Six were mounted on slides, the rest preserved in alcohol. These aedeagi were from specimens taken in Colorado, Nebraska, Oklahoma, and Texas.

The penis is arched, and the central bulge is long to accommodate an unusually long internal sac. The apex is nearly concentric when viewed from the inner side. The apical ridges are long but not prominent. The bulges on the mid-dorsal and mid-ventral sides are equal in size, but the ventral one is lower.

The internal sac is long, as noted by Rivalier (1954:252). The structures that form a central plate are feebly developed, so much so that the tip, or tooth that caps the central plate, is reduced to a very small scutum (Fig. 2, c and d). Other structures are well developed, especially so in the great length of the large stiffening rib, and long filiform flagellum with its loose basal whorl. The elongated sac resembles the general design found in species of the subgenus *Habroscelimorpha*, also mentioned by Rivalier (1954:252), and depicted, in part, by Rumpp (1957:146–147), but it differs internally where the flagellum of *C. scutellaris* does not sustain a membrane.

In the copulatory evaginated position, the internal sac of *C. scutellaris* everts at an acute angle of about 25° from the centerline of the penis. This is similar to the process in most of the species of *Cicindela* (sensu Rivalier). The everted

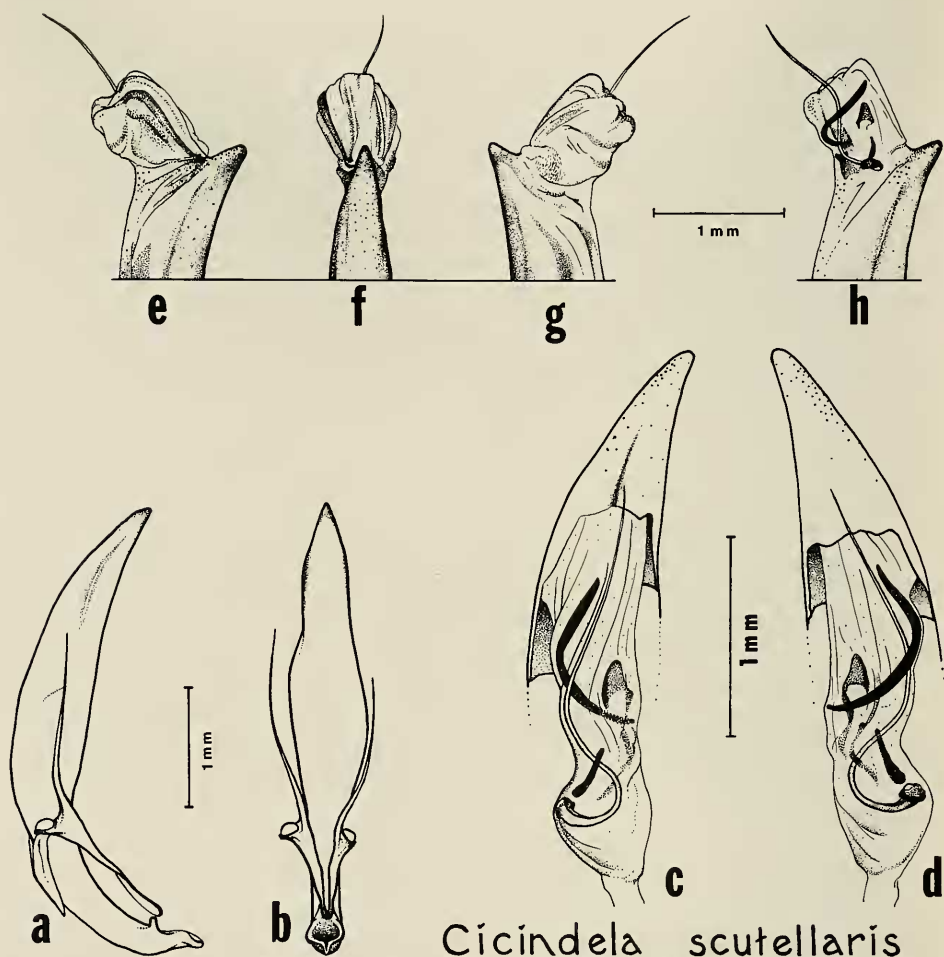


Fig. 2. Aedeagus of *Cicindela scutellaris*. View *a* and *b* of the dorsal and inner sides of the penis, ssp. *scutellaris* (Lakeside, NE); views *c* and *d* of the dorsal and ventral sides of the internal sac, ssp. *rugata* (Nacogdoches, TX); *e*, *f*, and *g* are views of the everted sac, ssp. nov. (Maybell, CO—type location); *h* is a through view of the everted sac showing location of the sclerites, ssp. *scutellaris* (Boise City, OK).

convolutions are uncomplicated, and the external fields are not pronounced. There is no apical fold near the ventral side. This departure from other species may have induced advanced development of the flagellum and large stiffening rib, while concurrently inducing atrophy of the tooth structure.

Female. — The external genitalia are shown in Fig. 3. The cleft in the hypopygium is V-shaped, much as it is in closely related species of the *Purpurea* Group. The styli are long, and the tip of the proctiger is wider at the top than in either *C. formosa* or the species of the *Purpurea* Group.

Conclusion. — The placement of *C. scutellaris* in Rivalier's phylogeny is correct. However, the slight morphological departure from *Cicindela* (sensu Rivalier) does not warrant his erecting the separate subgenus *Pachydela* for this one species. The

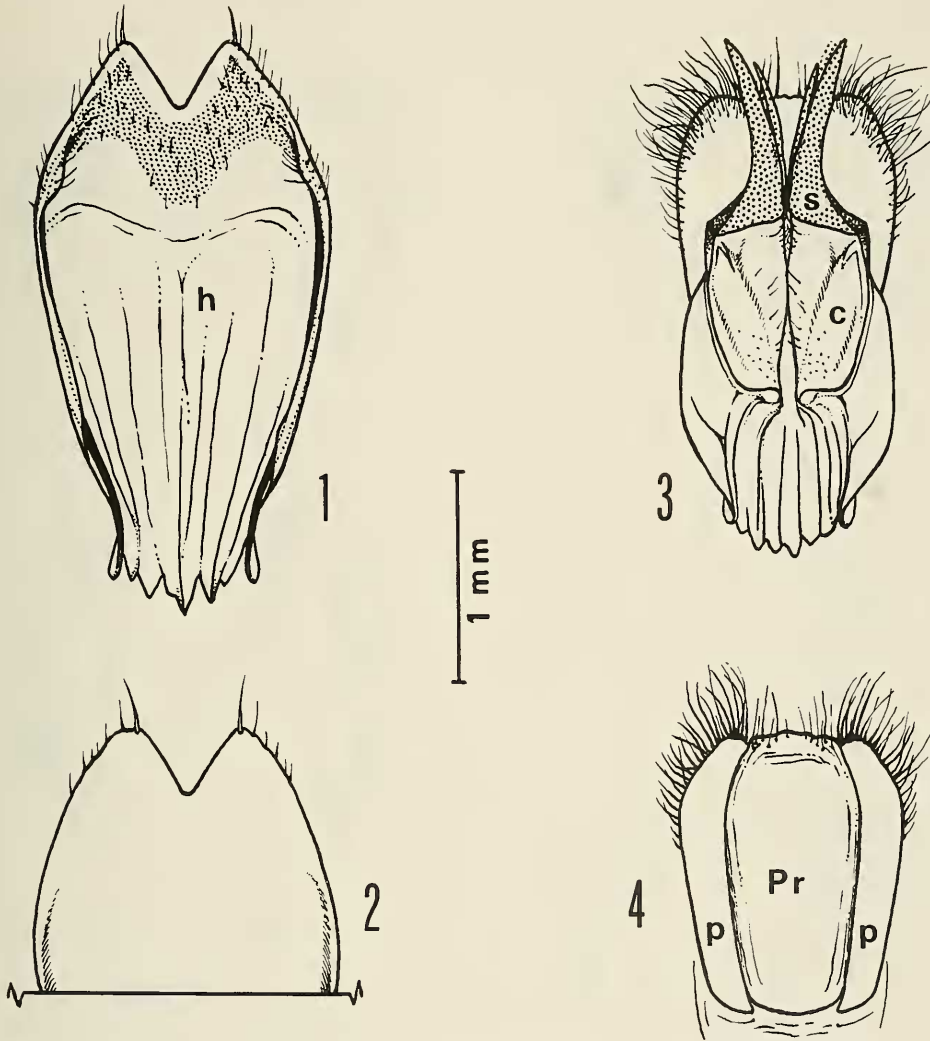


Fig. 3. *Cicindela scutellaris yampae*, external female genitalia. 1. Dorsal, or inside view of sternum eight (hypopygium); 2. Ventral, or outer view of sternum eight—upper part only; 3. Ventral view of second gonocoxa (coxite) and second gonopophysis (stylus); 4. Dorsal view of syntergum 9 and 10 (proctiger and paraprocts).

name *Pachydela* remains a junior synonym of *Cicindela* as recorded in the Check-list of Cicindelidae by H.P. Boyd et al. (1982:6).

Genitalia of *Cicindela formosa*

Figures 4 and 5

Male.—Twenty-seven aedeagi were examined in both the resting and everted positions. Of these, 12 were mounted on slides, and 15 were preserved in alcohol. These organs were extracted from specimens collected in Colorado, Oklahoma, Texas, and New Mexico.

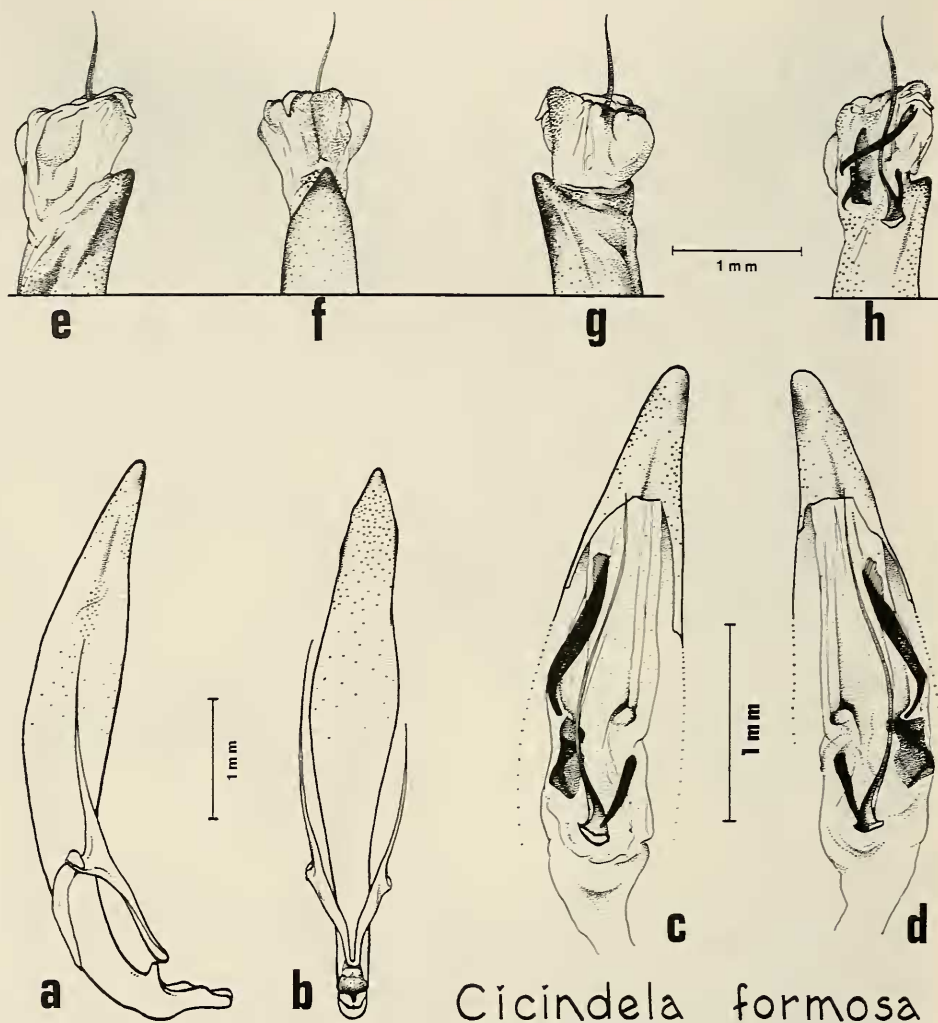


Fig. 4. Aedeagus of *Cicindela formosa*. View *a* of the dorsal side of the penis; *b* of the inner side; *c* and *d* the dorsal and ventral sides of the internal sac, ssp. nov. (Mescalero Sands, NM—type location); *e*, *f*, *g*, and *h* are views of the everted sac, ssp. *gibsoni* (Maybell, CO).

The penis of *C. formosa* is proportionately small for a tiger beetle of its size (Fig. 4, *a* and *b*). It is smooth on the exterior, and only slightly arched. The lateral ridges are not pronounced. The overall shape is nearly concentric, with no bulges on either the dorsal or ventral side.

Rivalier (1954:253) erected Group VII, designating *C. formosa* as the type species. Included in this group were *C. purpurea*, *C. limbalis*, and *C. sexguttata*, all because the penis was not arched, the internal sac was provided with a thin flagellum, and a median tooth was claimed to be absent. Such a description seems to fit *C. formosa* to some degree, as shown in Fig. 4. However, it does differ radically from the other species placed in Group VII because it does not possess a median tooth, whereas the others do.

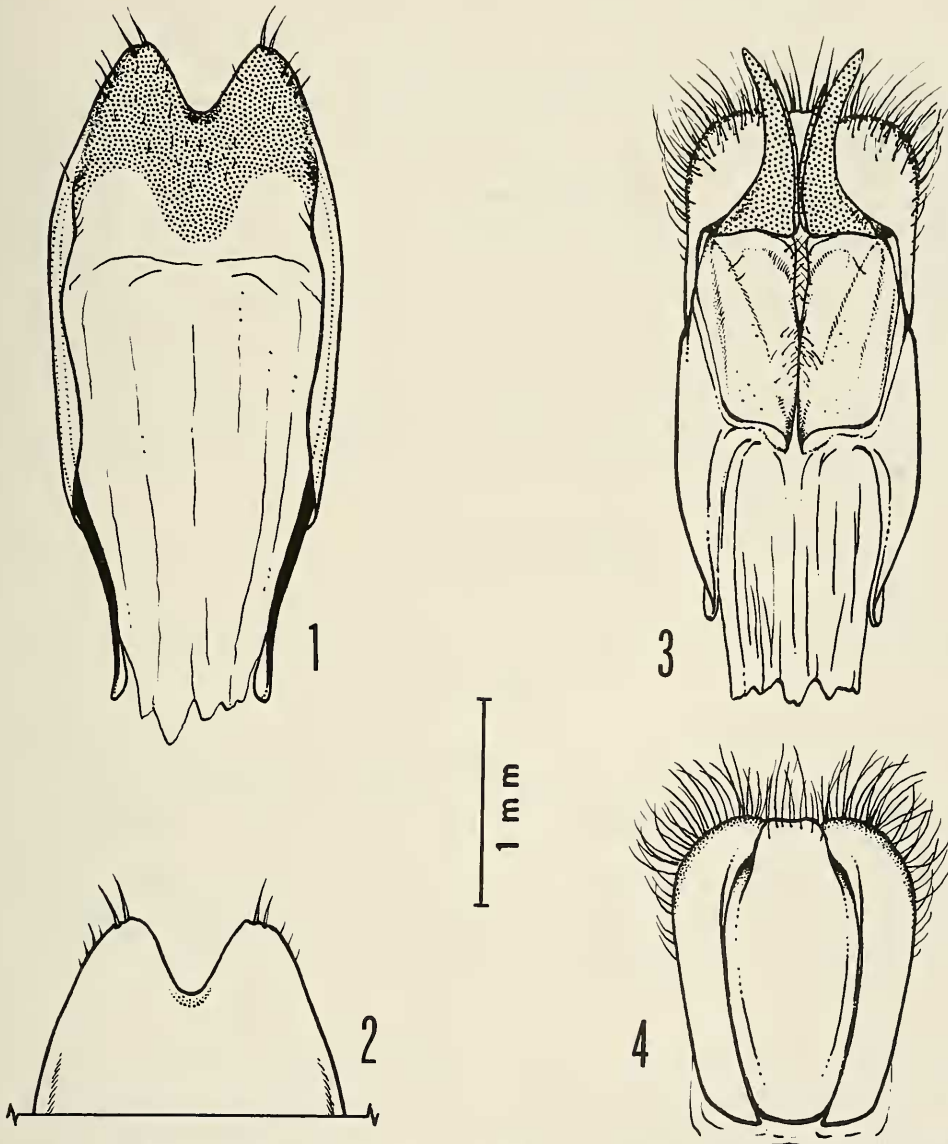


Fig. 5. *Cicindela formosa rutilovirescens*, external female genitalia. 1. Dorsal, or inside view of sternum eight (hypopygium) h; 2. Ventral or outer view of sternum eight—upper party only; 3. Ventral view of second gonocoxa (coxite) c and second gonopophysis (stylus) s; 4. Dorsal view of syntergum 9 and 10 (proctiger and paraprocts) Pr&p.

Another significant departure from other species in Rivalier's Group VII is the unique development of the everted sac shown in Fig. 4 (e, f, g, and h). In *C. formosa* the internal sac everts apically, nearly in line with the centerline of the penis, and not at the angle so typical of the other species in Rivalier's Group VII. The eversion of the *C. formosa* sac is at an angle similar to the eversion of the sac in species of the subgenus *Habroscelimorpha*, but otherwise differs from these



● *C. formosa rutilovirescens* ■ *C. scutellaris yampae*
 ⊕ hybrid: *formosa* X *rutilovirescens*

Fig. 6. Map of a portion of southwestern United States showing location of some new tiger beetles of the Genus *Cicindela*.

by having a median tooth and a stubby-based flagellum that does not sustain a large membrane.

Female.—The external female genitalia are shown in Fig. 5. The outstanding feature is the curved bottom of the hypopygium notch. This is a radical departure

from all other species in Rivalier's Group VII; these other species have an acute angle to their hypopygium notches.

Conclusion.—From an evolutionary standpoint, *C. formosa* fits into a singular niche of the subgenus *Cicindela*. It is a species with adults equal in size to, or larger than, those of the *Longilabris*, *Pulchra*, or *Tranquebarica* Groups. Ecologically it is adapted to the various climates and environments of the upper North American continent where it remains fixed in a sand-dwelling niche. It has an extensive distribution across the United States and Canada, from the Rocky Mountains to the eastern seaboard. The generic features of this species have few attributes to fix its ancestral type with other extant species. Therefore, it must be assumed that its derivation stems from great antiquity. It is a singular development of the Nearctic regions.

Phylogenetically *Cicindela formosa* fits between the *Scutellaris* Group (sand blowout habitat; long internal sac of the aedeagus, with long unsustained flagellum and atrophied tooth), and the *Purpurea* Group (coarse sand habitat; internal sac of the aedeagus with a very small tooth and a short sinuous flagellum).

Referenced Locations

Figure 6

Locations are shown on this map with reference to *C. scutellaris yampae* and *C. formosa rutilovirescens*.

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